Carefully Evaluate Satellite-Launcher Interface

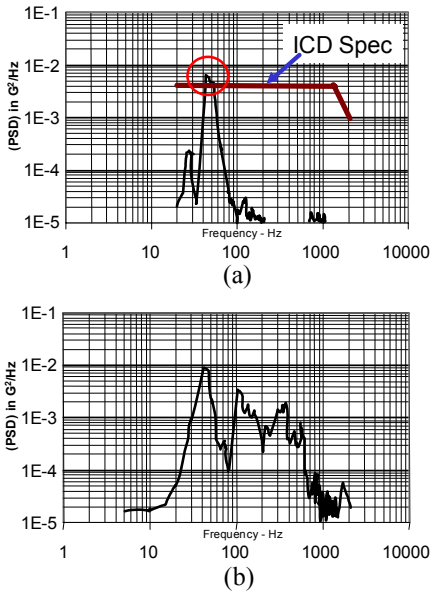
The Problem:

An experimental spacecraft fell silent after having been successfully released from the launch vehicle. This failure was deemed to have occurred because unexpectedly high vibration developed in the launch vehicle before it was air-dropped, imparting stress in the satellite beyond its design limit.

The Cause:

This failure was caused primarily by a satellite-launcher interface problem:

- The booster, while being carried by the launching airplane, vibrated at 40-50 Hz. In several previous flights, shaking went beyond the level spelled out in the Interface Control Document (ICD). As a result, the rocket contractor reduced the airplane's speed to minimize this problem. Still, vibration in this flight was double the specification.
- The satellite exhibited a structural resonance at 40 Hz. During factory test, this resonance amplified an acceleration input six-fold.
- The satellite contractor conducted the vibration acceptance test at a lower level than the ICD specification. A defect in the electronics or harness probably went undetected in the test, but propagated under a combination of excessive in-flight vibration and resonance to cause the failure.



Vibrational forces, expressed as power spectral density (PSD) in log scale (a) imparted on the spacecraft by the carrier airplane, and (b) as satellite's response toward an even level of excitation. Spacecraft resonated at the frequency where above-spec shaking took place.

- Both the launcher and the satellite prime contractors recognized the vibration issue and proposed to conduct a coupled-loads analysis. It was not performed because the program office, which served as the overall systems integrator, lacked funds.

Lessons Learned:

- Cables and connectors must be designed to withstand vibration-induced stresses.
- Margins must be reserved both in dynamic input estimation and in design.
- The interfaces among different organizations, particularly between the spacecraft side and the launcher side, frequently lead to problems. Independent analysis is advised to overcome organizational barriers (see Lesson No. 2).

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